Partial Translation of JP 2002-018248

[0037]

[Detailed Description of the Preferred Embodiment]

One embodiment of a spiral type gas-liquid contact membrane module according to the present invention will be described below. The description shown below covers the production of ozone water using ozone gas and pure water.

[0038]

Fig. 1 is an axial sectional diagram of a spiral type gas-liquid contact membrane module according to one embodiment of the present invention. Fig. 2 is a partially cutaway perspective diagram of a spiral type gas-liquid contact membrane element in the spiral type gas-liquid contact membrane module of Fig. 1. Fig. 3 is a sectional diagram taken along from the line A-A in Fig 1. Fig. 4 is an enlarged sectional diagram of the sealed portion of the spiral type gas-liquid contact membrane element of Fig. 1.

[0039]

The spiral type gas-liquid contact membrane module 1 shown in Fig. 1 includes a housing 2, which is a pressure vessel, and a spiral type gas-liquid contact membrane element 10 inserted into the interior of the housing 2. The housing 2 has a cylindrical body with a liquid inlet port 4 formed at one end 3 and with a gas-dissolved solution outlet port 6 formed on the other end 5. In addition, one or more gas outlets 7 are formed on the outer circumferential surface of the body of the housing 2.

[0040]

One end of a gas supply pipe 11, which is composed of a porous hollow pipe,

passes through one end 3 of the housing 2 to define a gas inlet port 11a. The other end thereof is tightly sealed with a resin agent 16. The wall of the gas supply pipe 11 is formed with a plurality of supply holes 11b so that pressure loss can be reduced with respect to the flow of gas supplied.

[0041]

In addition, as will be described later, a groove construction spacer 50 is wrapped about the outer perimeter of the spiral type gas-liquid contact membrane element 10.

[0042]

In Fig. 2, a spiral type gas-liquid contact membrane element 10 is defined by overlaying a hydrophobic porous membrane 14 on both surfaces of a liquid-side flow channel material 13, further overlaying two gas-side flow channel materials 15 on the other surface of the hydrophobic porous membrane 14 and wrapping these materials about the perimeter of the gas supply pipe 11.

[0043]

It is necessary to select a material for a member that will be in contact with ozone or ozone which has durability relative to ozone but also prevents any of the components of the member from seeping out. Typically fluorine resins are used. Especially tetrafluoroethylene resins (PTFE), perfluoroalkoxy resins (PFA) or New PFA are used in a preferred manner. New PFA is a purer fluorine resin having chemically most stable construction by changing both unstable end groups of PFA into CF_3 groups. In addition, vinylidene fluoride resins (PVDF) and perfluoroethylene-propylene resins (FEP) can be used, depending on applications and working conditions.

[0044]

This embodiment uses as a hydrophobic porous membrane 14 a flat

membrane composed of PTFE having a average pore diameter of 0.01 to 1 μm. This embodiment also uses as a liquid-side flow channel material 13 a net formed through the plain weaving of wire materials composed of PFA. A gas-side flow channel material 15 is also formed of PFA. In addition, a groove construction spacer 50 is formed of NewPFA.

[0045]

As shown in Fig. 3, a spiral space between hydrophobic porous membranes 14 holding a liquid-side flow channel material 13 therebetween forms a liquid-side flow channel 19. The inner-perimeter-side side portion (a side parallel with the gas supply pipe 11) and outer-perimeter-side side portion of the spiral liquid-side flow channel 19 are sealed by fusion welding the hydrophobic porous membranes 14 holding the liquid-side flow channel material 13 therebetween. This forms an inner-perimeter-side sealed portion 21a and an outer-perimeter-side sealed portion 21b on the inner-perimeter-side side portion and the outer-perimeter-side side portion, respectively, of the liquid-side flow channel 19. Therefore, the liquid-side flow channel 19 serves as a space that allows pure water and ozone water to flow in an axial direction of the spiral type gas-liquid contact membrane element 10. In addition, both axial ends of the liquid-side flow channel 19 are open, which allows the inflow of pure water and the outflow of ozone water.

[0046]

In this embodiment, two hydrophobic porous membranes 14 are fusion welded on opposite sides of the holding liquid-side flow channel material 13 therebetween. One hydrophobic porous membrane 14 may be folded to insert the liquid-side flow channel material 13 between and fusion weld one side portion thereof.

[0047]

A spiral space between the two hydrophobic porous membranes 14 holding the gas-side flow channel material 15 therebetween defines a gas-side flow channel 18. As shown in Fig. 4, both axial ends of the spiral gas-side flow channel 18 are sealed with a resin material 17. The resin material 17 is filled between both ends on the outer-peripheral surface of the spiral type gas-liquid contact membrane element 10 and the inner-peripheral surfaces of the body of the housing 2 for sealing purposes to form a cylindrical space 18a. This forms sealed portions 10b, 10c on both ends of the gas-side flow channel 18. Therefore, the gas-side flow channel 18 serves as space that allows ozone gas 25 to flow in a spiral direction of the spiral type gas-liquid contact membrane element 10. This enables the ozone gas 25 to flow from the cylindrical space 18a through a gas outlet port 7 out of the module.

[0048]

As described above, the gas-side flow channel 18 and the liquid-side flow channel 19 in the gas-liquid contact portion 10a, except the sealed portions 10b, 10c on both ends of the spiral type gas-liquid contact membrane element 10, are separated from each other by the hydrophobic porous membrane 14, an inner-perimeter-side seals portion 21a, an outer-perimeter-side sealed portion 21b, and the sealed portions 10b, 10c.

[0049]

Fig. 5 is a perspective diagram showing a groove construction spacer 50 wrapped about the outer perimeter of the spiral type gas-liquid contact membrane element 10 of Fig. 2. Fig. 6 is an axial sectional diagram of a spiral type gas-liquid contact membrane element 10 having a groove construction spacer 50 wrapped thereabout. Fig. 7 is a plan diagram showing one example of a groove construction spacer 50. Fig. 8 is a sectional diagram of a groove construction spacer 50.

[0050]

As shown in Fig. 5 and Fig. 6, a groove construction spacer 50 is wrapped about the outer perimeter of a spiral type gas-liquid contact membrane element 10. The groove construction spacer 50 may be wrapped about the element once or more times.

[0051]

A groove construction spacer 50 is, as shown in Figs. 7 and 8, composed of a plurality of warps 51 disposed in parallel and a plurality of wefts 52 disposed orthogonal to the warps 51. In this embodiment, each two warps 51 are bound to form a convex portion 54 and a groove portion 53 are formed between convex portions 54. The wefts 52 are used to fix the warps 51 at constant intervals.

[0052]

As shown in Fig. 5, a groove construction spacer 50 is wrapped about the outer perimeter of a spiral type gas-liquid contact membrane element 10 so that a groove portion 53 extends in a vertical direction with respect to an axial direction of the spiral type gas-liquid contact membrane element 10, as shown by an arrow R. In this embodiment, the groove construction spacer 50 is wrapped about the element four times.

[0053]

In the groove construction spacer 50 of Figs. 5 and 6, a warp having an outside diameter D smaller 100 μm causes the groove portion 53 to be shallow, thus resulting in an increase in gas and condensate flow resistance. This prevents the sufficient flow of a gas and a condensate, thereby making it impossible to smoothly discharge the condensate into the exterior. On the other hand, a warp 51 having an outside diameter D larger than 500 μm causes a larger outside diameter of the spiral type gas-liquid contact membrane element 10 including the groove construction spacer 50 and a

larger outside diameter of the housing 2. This leads to higher material costs and an increase in mounting space, thus resulting in diseconomy. It is therefore preferable that the outside diameter D of the warp 51 should range from 100 to 500 μm.

[0054]

A weft 52 having an outside diameter d smaller than 50 μm also makes it difficult to ensure the strength of the groove construction spacer 50. On the other hand, a weft 52 having an outside diameter d larger 250 μm causes a larger thickness of the groove construction spacer 50. The larger thickness causes a larger outside diameter of the spiral type gas-liquid contact membrane element 10 including the groove construction spacer 50 and a larger outside diameter of the housing 2. This leads to higher material costs and an increase in mounting space, thus resulting in diseconomy. It is therefore preferable that the outside diameter d of the weft 52 should range from 50 to 250 μm.

[0055]

In addition, the groove portion 53 having a width smaller than 200 μm prevents the sufficient flow of a gas and a condensate, thus making it difficult to promptly discharge the condensate into the exterior. On the other hand, the groove portion 53 having a width W larger than 1000 μm causes one groove construction spacer 50 to become embedded in the groove portion 53 of the other groove construction spacer 50, thus resulting in a narrower condensate flow channel, if these groove construction spacers 50 overlap. It is therefore preferable that the width W of the groove portion 53 should range from 200 to 1000 μm.

[0056]

In addition, the convex portion 54 between groove portions 53 having a width smaller than 200 μm can cause the groove construction spacer 50 to have a lower

strength, thus crushing the convex portion 54. On the other hand, the convex portion 54 having a width larger than 1000 μm causes the flow channel to become narrower, thus making it difficult to sufficiently discharge a condensate. It is therefore preferable that the width of the convex portion 54 should range from 200 to 1000 μm.

[0057]

In this embodiment, the outside diameter D of the warps 51 is 250 μm while the outside diameter d of the weft 52 is 80 μm. The width W of the groove portion 53 is 450 μm.

[0058]

During the operation of the spiral type gas-liquid contact membrane module 1 of Fig. 1, pure water 30 passes through the liquid inlet port 4 and flows into an inlet space 3a defined by one end 3 of the housing 2 and the end surface of the spiral type gas-liquid contact membrane element 10. The pure water then flows in an axial direction along the liquid-side flow channel material 13 in the liquid-side flow channel 19, as shown in Fig. 2.

[0059]

Meanwhile, as shown in Fig. 1, the ozone gas 25 is fed from the gas inlet port 11a to the interior of gas supply pipe 11. As shown in Fig. 3 the ozone gas 25 enters the gas-side flow channel 18 through the supply holes 11b in the side surface of the gas supply pipe 11 and flows along the gas-side flow channel material in a spiral in a direction orthogonal to the gas supply pipe 11. The ozone gas 25 then passes through the cylindrical space 18a inside the housing 2 before being discharged through the gas outlet port 7 to the exterior. Note that the flow of the ozone gas 25 in the gas-side flow channel 18 can be made uniform by providing the flow channel with a plurality of gas outlet ports 7.

[0060]

As shown in Fig. 2, at the gas-liquid contact portion 10a of the spiral type gas-liquid contact membrane element 10, the ozone gas 25 flowing in a spiral in a direction approximately orthogonal to the gas supply pipe 11 comes into contact with the pure water 30 flowing in parallel with the gas supply pipe 11 through the hydrophobic porous membrane 14. This causes the ozone gas 25 to penetrate through the hydrophobic porous membrane 14 before being dissolved in the pure water 30, thus producing ozone water 31.

[0061]

As shown in Fig. 1, the ozone water 31 flowing out of the end surface of the spiral type gas-liquid contact membrane element 10 flows through an outlet space 5a defined by the other end 5 of the housing 2 and the end surface of the spiral type gas-liquid contact membrane element 10 before being discharged through the gas-dissolved solution outlet port 6 to the exterior.

[0062]

As shown in Fig. 2, water vapor 9 generated in the liquid-side flow channel 19 of the spiral type gas-liquid contact membrane element 10 (see Fig. 3) penetrates through the hydrophobic porous membrane 14 and condenses in the gas-side flow channel 18 (see Fig. 3). Condensed water 8 thus generated flows in a spiral along the gas-side flow channel material 15 extending in a direction approximately orthogonal to the gas supply pipe 11 together with the ozone gas 25 before being discharged into the outer perimeter of the spiral type gas-liquid contact membrane element 10. The condensed water 8 flows together with the ozone gas 25 in a circumferential direction along the groove portion 53 of the groove construction spacer 50 extending in the direction approximately orthogonal to the gas supply pipe 11 before being discharged

through the gas outlet port 7. Because, in this case, the groove portion 53 of the groove construction spacer 50 extends linearly and continuously in a circumferential direction of the outer perimeter of the spiral type gas-liquid contact membrane element 10, the condensed water 8 can flow smoothly to the gas outlet port 7.

[0063]

As a result, the condensed water 8 does not stay in the gas-side flow channel 18, thus preventing a reduction in the effective membrane area of the hydrophobic porous membrane 14, which contributes to gas-liquid contact operation due to the ozone gas 25 and the pure water 30. Consequently, the concentration of the ozone water is kept constant. Because of the prevention of an increase in pressure loss in the gas-side flow channel 18 due to the condensed water 8, the pressure in the gas-side flow channel 18 also remains lower than that in the liquid-side flow channel 19. This prevents the production of problematic air bubbles in the liquid-side flow channel 19.

[0064]

Fig. 9 is a sectional diagram showing an alternative example of a groove construction spacer 50. In the groove construction spacer 50 shown in Fig. 9, convex portions 54 composed of a plurality of warps 51 are disposed on opposite sides of a plurality of wefts 52 with a groove portion 53 formed between convex portions. Therefore, the groove construction spacer 50 shown in Fig. 9 has a plurality of groove portion 53 on opposite sides thereof.

[0065]

Even if the groove construction spacer 50 shown in Fig. 9 is wrapped about the outer perimeter of a spiral type gas-liquid contact membrane element 10, condensed water generated in a gas-liquid side flow channel can be discharged through a gas outlet port 7 smoothly.

[0066]

[Examples]

Spiral type gas-liquid contact membrane modules of an example, a comparative example 1 and a comparative example 2 shown below were fabricated. Measurements were then made of gas-side pressure loss which increased due to condensed water undescended.

[0067]

In the example, the groove construction spacer 50 shown in Figs. 7 and 8 were wrapped about the outer perimeter of the spiral type gas-liquid contact membrane element 10 to fabricate a spiral type gas-liquid contact membrane module having a construction shown in Fig. 1.

[0068]

In the comparative example 1, a plain-woven net was wrapped about the outer perimeter of the spiral type gas-liquid contact membrane element 10 of Fig. 2 to fabricate a spiral type gas-liquid contact membrane module.

[0069]

In the comparative example 2, nothing was wrapped about the outer perimeter of the spiral type gas-liquid contact membrane element 10 of Fig. 2 to fabricate a spiral type gas-liquid contact membrane module.

[0070]

Note that in the example, comparative example 1 and comparative example 2, PTFE hydrophobic porous membrane NTF1121 was used as a hydrophobic porous membrane. For the size of the membrane module, the dome thereof has a diameter of 84 mm, a length of 310 mm and an effective membrane area of 0.5 m^2.

[0071]

An ozone gas with a 10% volume is fed through the gas inlet port 11a at different flow rates and 25°C pure water is fed through the liquid inlet port 4 at a pressure of 2 kgf/cm^2 and a flow rate of 5 l/min. Measurements were then made to determine a relation between a gas flow rate in the gas-side flow channel and pressure loss (pressure loss at condensation) on the gas flow channel side.

[0072]

Fig. 10 shows measurement results for a relation between gas flow rate and pressure loss in the gas-side flow channel for the example, comparative example 1 and comparative example 2.

[0073]

As shown in Fig. 10, the spiral type gas-liquid contact membrane module of the comparative example 2 with nothing wrapped about the spiral type gas-liquid contact membrane element 10 was unable to discharge condensed water out of the membrane module, thus resulting in an increase in pressure loss in the gas-side flow channel with an increase in flow rate.

[0074]

In addition, the spiral type gas-liquid contact membrane module of the comparative example 1 with the plain-woven net wrapped about the outer perimeter of the spiral type gas-liquid contact membrane element 10 showed a smaller increase in pressure loss than that of the comparative example 2.

[0075]

On the other hand, the spiral type gas-liquid contact membrane module of the example with the groove construction spacer 50 wrapped about the spiral type gas-liquid contact membrane element 10 was able to discharge condensed water out of the membrane module at all times, thus resulting in the smallest increase in pressure loss in

the gas-side flow channel with an increase in flow rate.

[0076]

From these results, it can be seen that condensed water can be discharged out of the module smoothly by wrapping the groove construction spacer 50 about the outer perimeter of the spiral type gas-liquid contact membrane element 10.

[0077]

As described above, in the spiral type gas-liquid contact membrane module of the present invention any condense water flows through the groove portion 53 of the groove construction spacer 50 before being discharged into the exterior smoothly. This makes it possible to supply a gas-dissolved solution have a constant concentration.

[Brief Description of the Drawings]

Fig. 1 is an axial sectional diagram of a spiral type gas-liquid contact membrane module of one embodiment according to the present invention;

Fig. 2 is a partially cutaway perspective diagram of a spiral type gas-liquid contact membrane element in the spiral type gas-liquid contacts membrane module of Fig. 1;

Fig. 3 is a sectional diagram taken along from the line A-A in Fig 1;

Fig. 4 is an enlarged sectional diagram of the sealed portion of the spiral type gas-liquid contact membrane element of Fig. 1;

Fig. 5 is a perspective diagram showing a groove construction spacer 50 wrapped about a spiral type gas-liquid contact membrane element;

Fig. 6 is a sectional diagram of a spiral type gas-liquid contact membrane element having a groove construction spacer wrapped thereabout;

Fig. 7 is a plan diagram showing one example of a groove construction spacer;

Fig. 8 is a sectional diagram of one example of a groove construction spacer;

Fig. 9 is a sectional diagram showing an alternative example of a groove construction spacer; and

Fig. 10 shows measurement results for a relation between gas flow rate in a gas-side flow channel and pressure loss on a gas flow channel side in spiral type gas-liquid contact membrane modules of an example, a comparative example 1 and a comparative example 2.

[Description of the Reference Numerals and Signs]

1: Spiral type gas-liquid contact membrane module

2: Housing

3a: Inlet space

4: Liquid inlet port

5a: Outlet space

6: Gas-dissolved solution outlet port

7: Gas outlet port

10: Spiral type gas-liquid contact membrane element

10b, 10c: Sealed portion

11: Gas supply pipe

11a: Gas inlet port

13: Liquid-side flow channel material

14: Hydrophobic porous membrane

15: Gas-side flow channel material

18: Gas-side flow channel

18a: Cylindrical space

19: Liquid-side flow channel

21a: Inner-perimeter-side sealed portion

21b: Outer-perimeter-side sealed portion

50: Groove construction spacer

51: Warp

52: Weft

53: Groove portion

54: Convex portion